NISTTech

ZERO THERMAL EXPANSION, LOW HEAT TRANSFER, VARIABLE TEMPERATURE SAMPLE ASSEMBLY FOR PROBE MICROSCOPY

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Applications

- **Application for SP< Apparatus**
  The invention has particular application for SPM apparatus designed to operate in ambient temperature and pressure environments because of the difficulties such apparatus have in controlling thermal distortion. This is in contrast to SPM apparatus designed to operate in high-vacuum or cryogenic fluid environments, where thermal distortion is easier to control. The invention comprises an inexpensive add-on that is adaptable to many commercial platforms.
- **Variable Temperature Measurements**
  In addition to SPM, this invention may also be applicable for variable-temperature measurements using techniques, such as optical microscopy and Raman spectroscopy, where position stability is required for imaging and three-dimensional mapping.

Advantages

- **Improvement over conventional SPM apparatus**
  The invention overcomes many problems associated with conventional SPM apparatus when operated at elevated temperature by reducing image problems at the atomic scale and range problems at the microscale caused by differential thermal expansion. Thus, new applications or extended analyses are possible.
- **Prevention of large thermal variations**
  Standard commercial, high-resolution SPMs typically include a piezoelectric-driven sample scanning stage that is sensitive to temperature. This invention prevents large thermal variations in the scanning stage that can lead to drift, false spatial calibration, and irreversible damage to the stage material. The restricted motion of the top surface of the sample puck allows for local imaging over a broad temperature range with minimal vertical drift.

Abstract

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The invention is a specimen sample mounting arrangement for Scanning Probe Microscope (SPM) apparatus (also known as Atomic Force Microscopes) which provides a nearly uniform and flat specimen mounting surface for scanning at different temperatures. ;SPM apparatus provide high-resolution images of extremely small surface features, allowing observation and manipulation of molecular and atomic level features.

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The invention maintains the upper horizontal surface of the specimen sample in the sample holder in a nearly fixed vertical location. This is accomplished by the design of the support apparatus and by reducing the rate of heat transfer between the sample holder and the SPM apparatus, thus permitting operation of the SPM at temperatures significantly above and below ambient with little or no thermally induced distortion.

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As shown, the subject sample holder with its embedded heater assembly consists of a thin cylindrical disk (called a sample puck), which contains both the sample being measured (not shown) attached to the upper surface, and the resistance heater embedded in the lower surface. ;The sample puck is fabricated from a material with very high thermal conductivity, such as Boron Nitride. ;Thus, the sample puck maintains a relatively uniform temperature when heated. ;In operation, electrical power input to the resistance heater elevates the sample puck to the temperature desired for measurement.

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Thermal distortion of the sample is reduced because the top surface of the sample puck is secured to the lower surface of cantilevered arms which extend horizontally from the tops of the support posts. This configuration preferentially limits thermal expansion of the sample puck to the downward vertical direction, leading to minimal motion of the top surface of the sample puck. Because the support posts are fabricated from very-low thermal expansion materials, such as certain nickel/iron alloys (commercially Invar) or certain glass ceramics (commercially Zerodur), heat conducted from the elevated temperature sample holder to the support posts results in very limited thermal movement.

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The device also has a reduced rate of heat transfer from the specimen sample holder to the SPM apparatus by physical separation. Thus, conductive transfer is eliminated and only convective and radiative heat transfer occurs across the air gap separating the lower surface of the sample puck from the SPM's stage holder. This rate of heat transfer can be further reduced by attaching an insulating material to the bottom surface of the sample puck.

Status of Availability

This invention is available for licensing exclusively or non-exclusively in any field of use.

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